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ROBERT FULTON CO.
NEWTOWN CONNECTICUT

REPORT NUMBER: FMS-R
DATE: 8 NOVEMBER, 1961

FINAL TECHNICAL REPORT

on the

FULTON

HIGH-SPEED, MULT - SWIMMER

PICKUP SYSTEM

for

OPERATIONS OF

UNDERWATER DEMOLITION UNITS

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Under

U. S. OFFICE OF NAVAL RESEARCH
CONTRACT NONR-2436(OO).

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ABSTRACT

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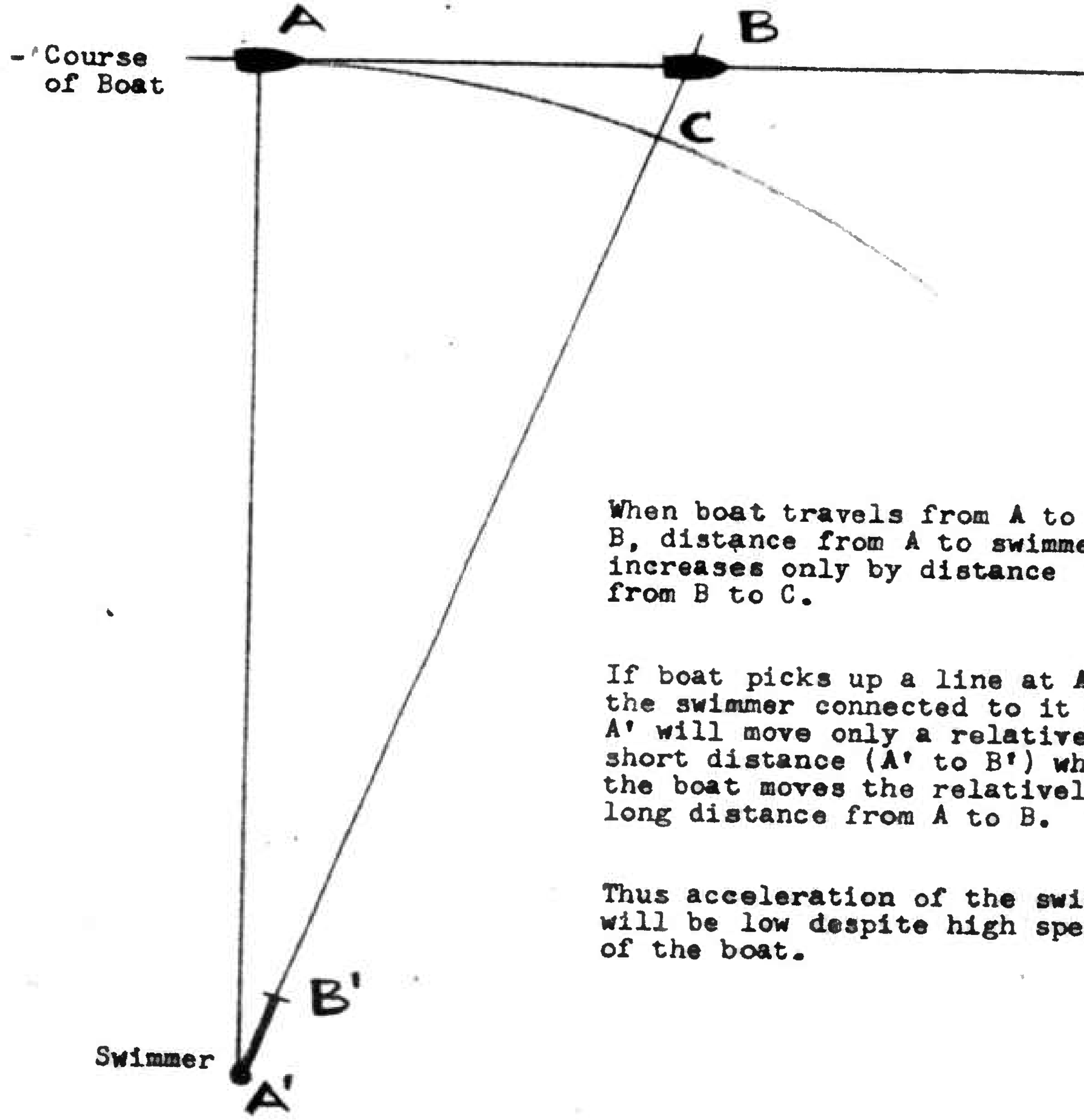
The nature of Underwater Demolition Team operations requires the maximum speed and efficiency of personnel recovery.

The system described below provides such a water-to-water capability. It has repeatedly demonstrated that it can pick up a complete complement of 20 men simultaneously, smoothly accelerate them from a static condition in the water to the maximum speed of presently available recovery craft, and quickly bring them aboard without slowing down.

It will work in rougher seas than other presently known techniques and has the advantage of permitting an exhausted or injured man to be assisted by his team mates without materially affecting the speed of the recovery. Overall ease of the operation is an important feature since pickup of the swimmers occurs at the end of what is generally a physically exhausting and hazardous exercise and, by other methods, has always required the utmost physical strength and coordination when the men are least able to provide it.

This report describes development of the system since its inception by The Robert Fulton Company.

BASIC PRINCIPAL OF OPERATION



When boat travels from A to B, distance from A to swimmer increases only by distance from B to C.

If boat picks up a line at A, the swimmer connected to it at A' will move only a relatively short distance (A' to B') while the boat moves the relatively long distance from A to B.

Thus acceleration of the swimmer will be low despite high speed of the boat.

GENERAL EQUIPMENT INSTALLATION

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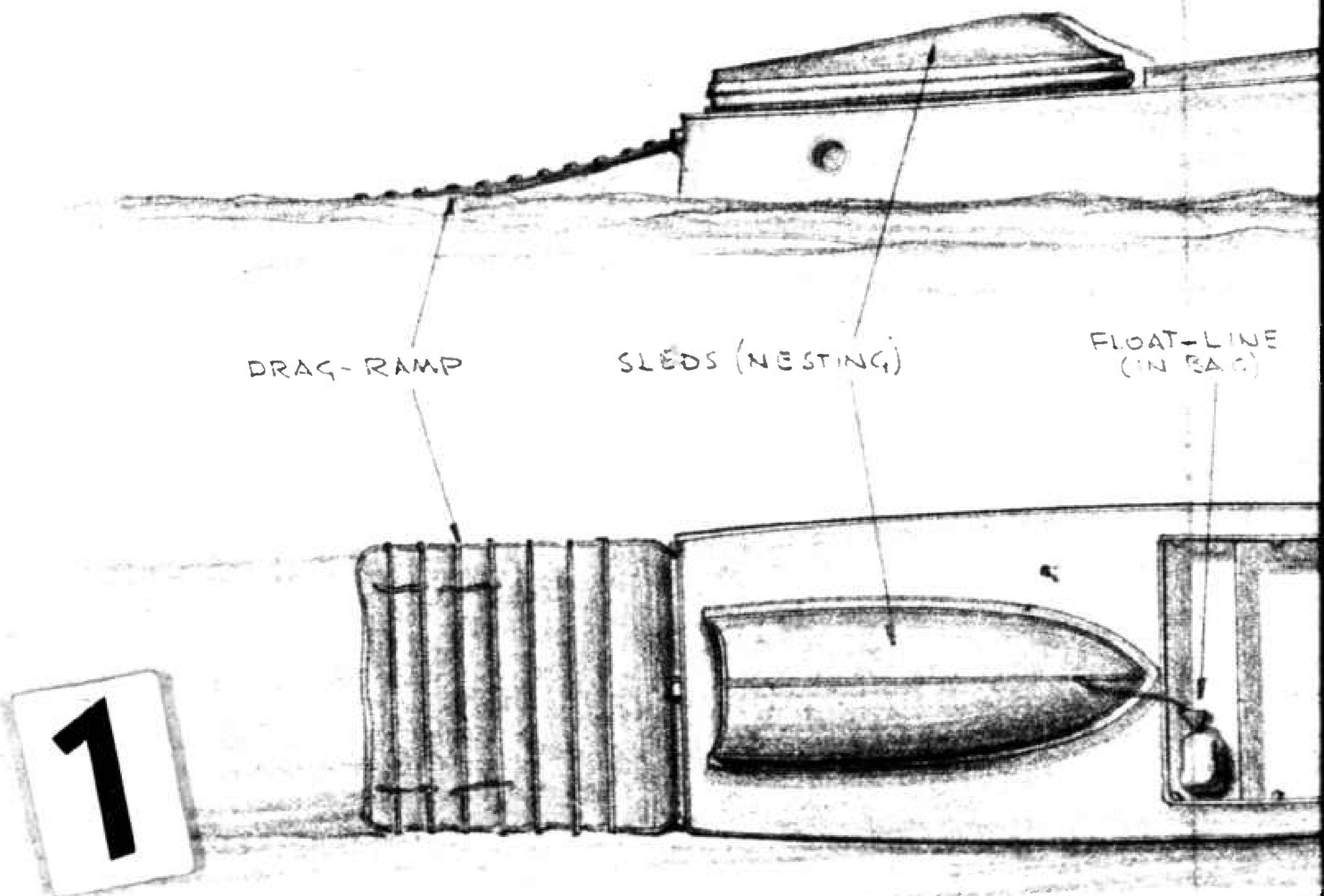
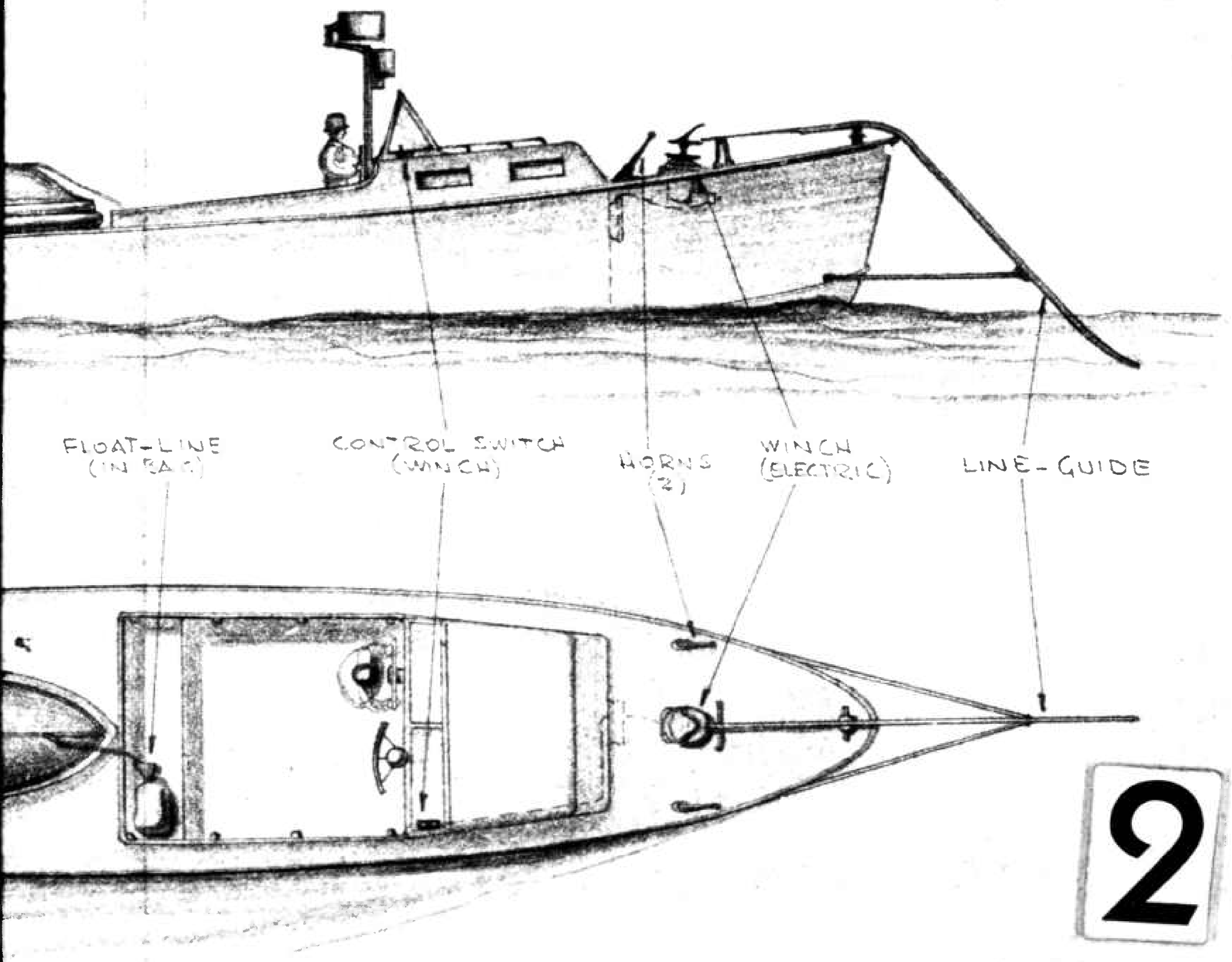


To apply the pickup principal operationally requires installation of the following equipment on the pickup boat:



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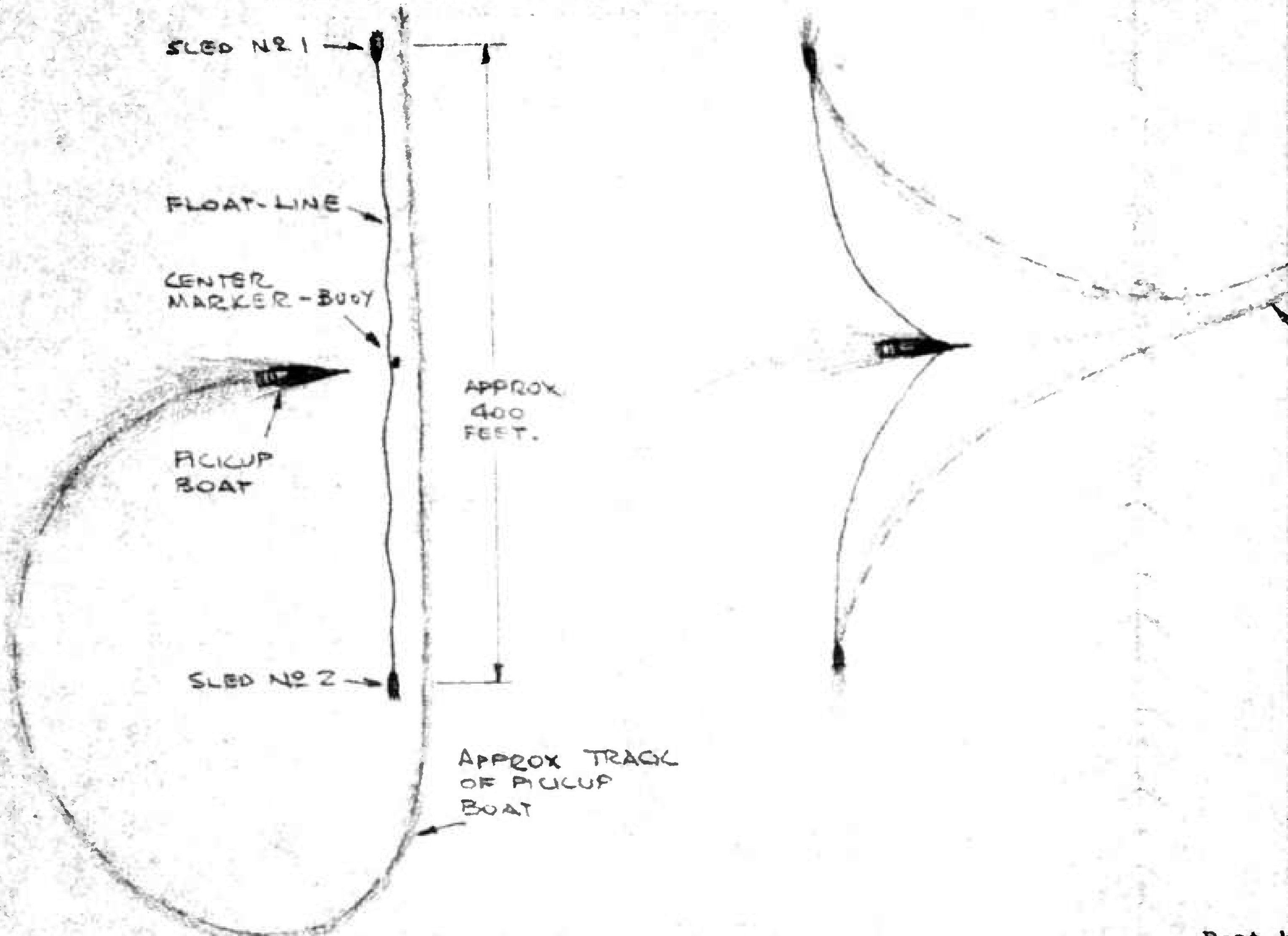
OPERATIONAL SCHEMATIC

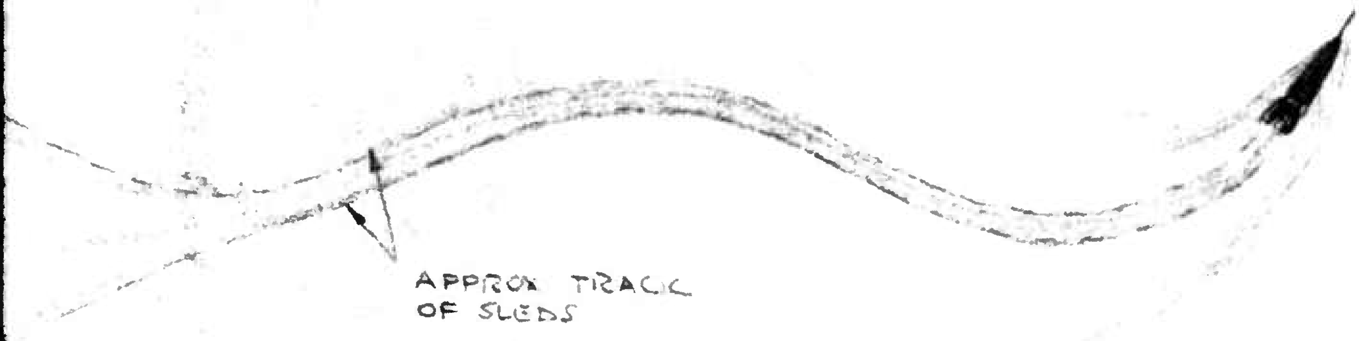


I. Boat drops #1 Sled by 1st group of swimmers, pays out float-line at full speed and drops #2 Sled by 2nd group, then executes 270° turn into line at marker-buoy.

II. Boat intercepts tow-line (Plenty of room to maneuver). Sleds are slowly accelerated as tow-lines slide up line-guide into winch on bow.

Boat h
at one

1



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w-line
man-
e slow-
tow-
e-guide

Boat has all swimmers in tow at one quick pass.

III. Winch starts rotating on bow, hauling sleds in simultaneously as boat heads to sea, executes evasive maneuvers.

NOTE

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The basic concept for the High-Speed, Multi-Swimmer Pickup System originated with the Robert Fulton Company and was presented to the Office of Naval Research for study and evaluation. This resulted in a 3-Phase program as follows:

Phase I	Concept Feasibility Phase
Phase II	Prototype Phase
Phase III	Operational Phase

The program and results of each Phase are described below.

PHASE I -- CONCEPT FEASIBILITY PHASE

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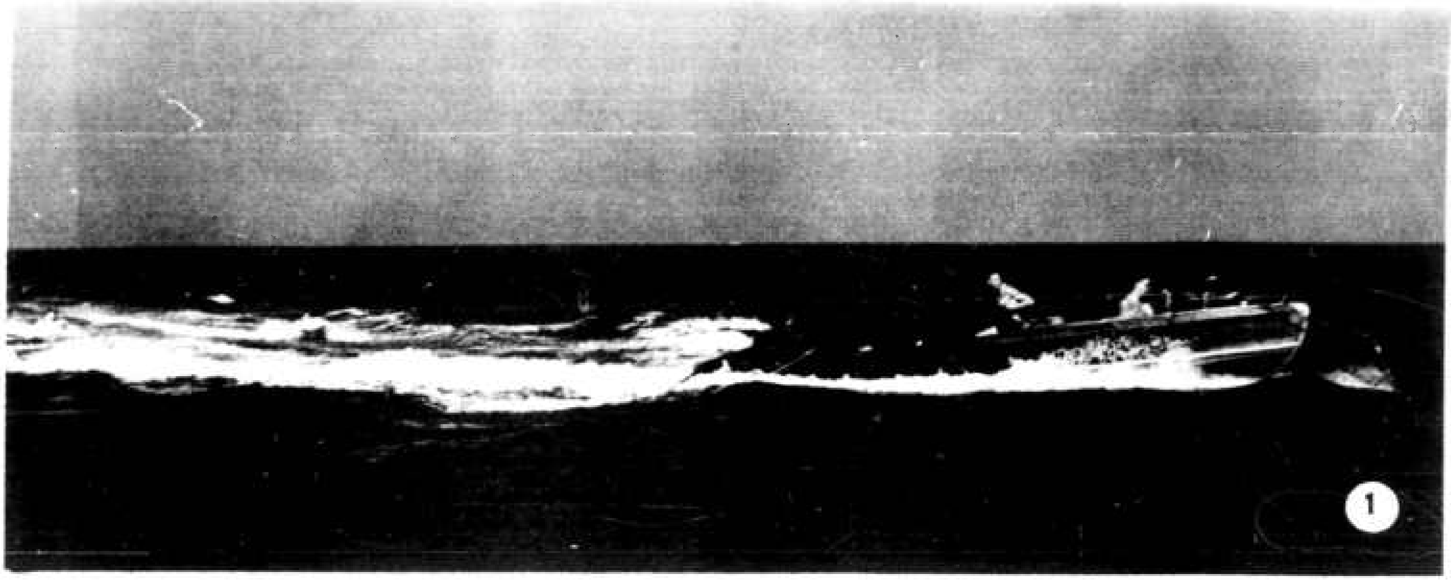
The purpose of this initial Phase was to determine, on a small and economical scale, whether or not the basic concept was sound.

The original plan was for the swimmers to be outfitted with small, inflatable rafts. Each would have his own secured to him and would employ an integral CO_2 bottle when time came for inflation.

Each raft would have a length of line and a snap for securing it to the next swimmer's unit. When all were attached together the line would be a satisfactory length for pickup and, although each man rode on his own raft, they would all be accelerated and towed away simultaneously. During the ensuing reel-in operation they would be brought aboard individually by funnelling into the open stern of rubber rafts towed on each side of the pickup boat.

For initial testing of this approach a small speedboat capable of approximately 30 knots was equipped with a jury-rigged line-guide on its bow and a single life raft was secured near its stern. Photograph (1) shows the pickup boat underway.

A rough initial tow-trial was conducted, with a toboggan (Photograph (2)) which worked painfully. The cleats across the bottom were rib-crackers and the turned up front end was too close a hazard.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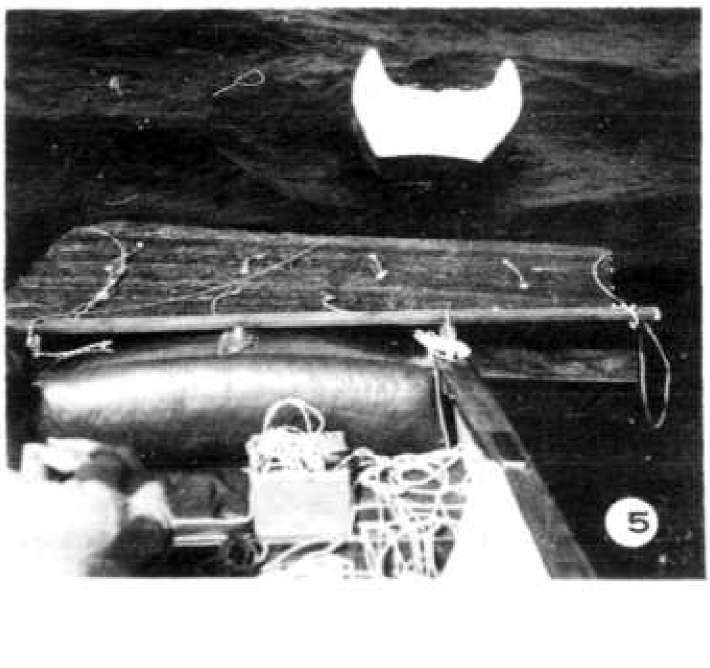
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Styrofoam slabs (Photograph (3)) were then reinforced with fiberglass and proved better but still quite uncomfortable in rough water. However, they were good enough to test the acceleration forces. Floatable polyethylene lines varying in length from 200 to 400 feet were tied at each end to a styrofoam raft and pickups were made at gradually increasing speeds. It was quickly apparent that the acceleration force was of minor concern and that by adjusting the line length pickups could satisfactorily be accomplished even at full speed of the pickup boat. Photograph (1) shows the speedboat with the float-line already scooped out of the water and locked on the bow and two swimmers aboard the rafts swinging into line astern.

To soften the ride, inflatable rubber rafts (Photograph (4) were substituted for the solid styrofoam ones. While they proved a distinct improvement, at high boat speeds even small waves caused excessive pounding which a swimmer could not long endure, nor could the rafts which were prone to split their seams and leave the man planing on his chest, a condition which even the hardiest can survive only briefly.

Difficulties with the rubber life-raft secured to the side of the pickup boat were also encountered. With speed the raft would actually become airborne and, in a crosswind, would flop right over on the top of the pickup boat. Boarding such a flying platform added to the swimmers' problems.

The solution to this difficulty and to that of the individual pickup rafts came simultaneously with the ideas of the "Sled" and the "Drag Ramp" (See photograph (5)). Putting

the swimmer in a small boat would give him an acceptable ride and protect him from being washed overboard. But the small boat would ride on the surface of the sea and be too easy to detect while the swimmers were awaiting pickup. Consequently the transom was removed and a flotation ring added around the gunwall. This permitted water to flood the boat to the point where only the swimmer's head would be protruding. Yet as soon as the pickup occured the "sled" would come right to the surface, the water in it essentially standing still while the hull simply left it behind, rose to the surface and started planing.

For boarding the pickup boat from such sleds a "drag ramp" was mounted across the transom of the pickup boat. This was essentially a canvas tarpaulin reinforced with wooden batons. Dragging astern, it provided a flexible yet firm supporting structure upon which the sleds could beach, permitting the swimmers to step aboard the pickup boat.

Riding as it does in the immediate wake of the boat, the ramp lies quietly on the surface and presents no problems even in a rough sea.

As the sleds are hauled in they remain on opposite sides of the propeller's cox-comb, sliding down off it and immediately swinging back onto the drag-ramp in one smooth motion.

The principal remaining question was whether or not a series of such sleds could be accelerated and towed. Photograph (6) shows such a string successfully in tow.

All the tests were conducted on Long Island Sound in April and May under conditions varying from calm to sea-state three. The results were encouraging, indicating that the concept was sound and justified proceeding with Phase II.

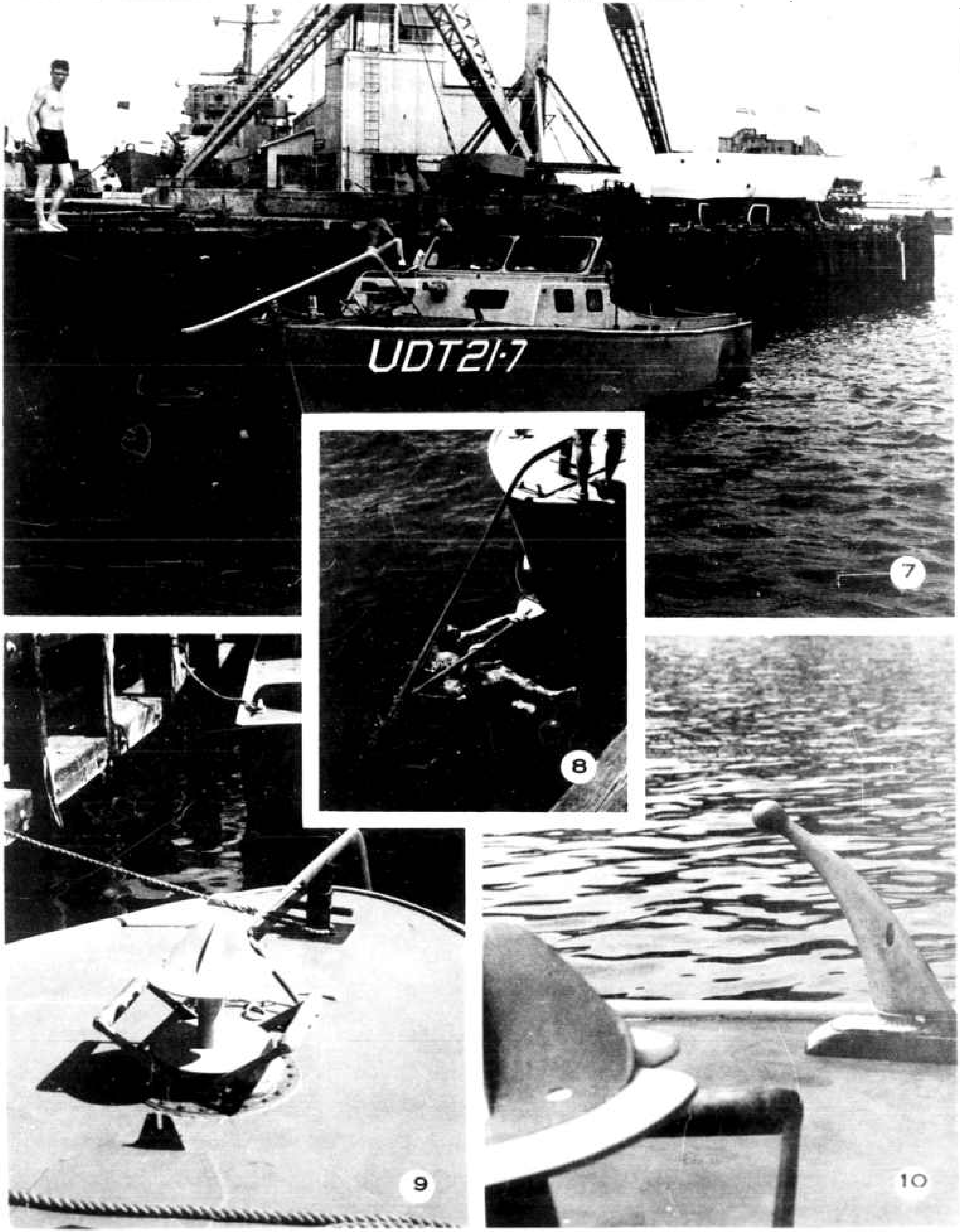
PHASE II - PROTOTYPE PHASE

****

The purpose of this phase was to design, build and test a prototype installation on a boat of the type used by the Navy Underwater Demolition Teams.

A 40 foot, 450 HP turbine-equipped experimental boat assigned to UDT 21 stationed at the Naval Amphibious Base, Little Creek, Virginia, was made available for the purpose. Photograph (7) shows the installation of the line-guide in its retracted position (out of the water). Photograph (8) shows it lowered into the water, the sway-brace cables in the process of being installed. Photograph (9) illustrates the winch used for hauling in the float-line and sleds. It is mounted in a manhole cover bolted onto the deck. The gear box and drive motor are below the deck. Extending upward thru the deck is a vertical spindle supporting the line-winding drum. To feed the float-line into the drum and lock it in place, an inclined "shoe" is mounted on its top, a slot is cut across the upper flange and a pair of eccentric jaws are located in the slot. A continuation of the line-guide runs aft from the bow and directs the float-line against the shoe which deflects it downward into the slot where it locks between the jaws.

Pivoting on shafts extending fore and aft thru the gear box are a pair of arms which support rollers. The arms are simultaneously driven up and down by internal cams geared to



7 8 9 10

the drum-driving shaft. As the drum rotates the arms travel up and down thereby winding the float-line evenly.

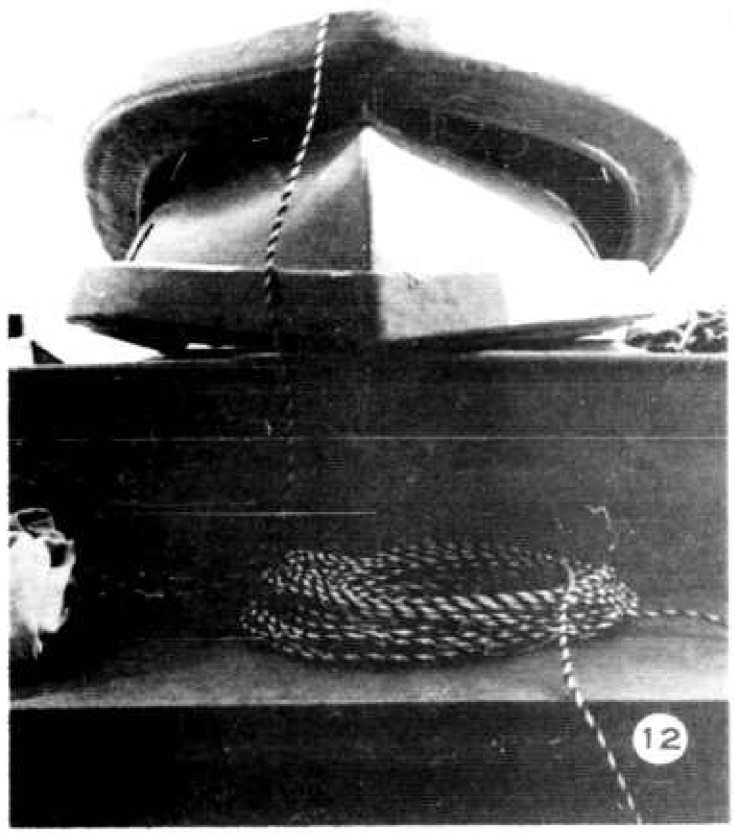
Mounted approximately athwart ship from the winch were two "Horns" (see photograph (10)]. These aligned the float-line with the level-wind rollers and led it aft along the two gunwalls and over the stern. A needle-bearing supported roller was fitted into the base of each horn. The horns themselves were each secured with three 3/8" dia. bolts thru the deck and thru a 1/8" thick steel reinforcing plate under the deck.

Five sleds of three different sizes and designs were constructed. All were built of fiberglass with polyester and epoxy resins. All had their transoms removed, a reinforced stern opening, a form of floatation-ring around the gunwall, padding in the bottom and hand-holes thru their sides. One was an 8 foot pram type (with a blunt bow, a vee-bottom and relatively straight sides) and had a wide floatation ring. (See photograph 11). Two were 8 footers with round bottoms and relatively small floatation rings. (See photograph (12). The remaining two were 10 footers, also with relatively narrow floatation rings. (See photograph (14).

The float-line was made of polyethylene constructed in the manner of normal layed manila rope. It was colored yellow and black to test its visibility under various water and light conditions. Photograph (12) shows it attached to a pair of nested sleds on the after deck of the pickup boat.

A drag-ramp of the type shown in photograph (15) was


11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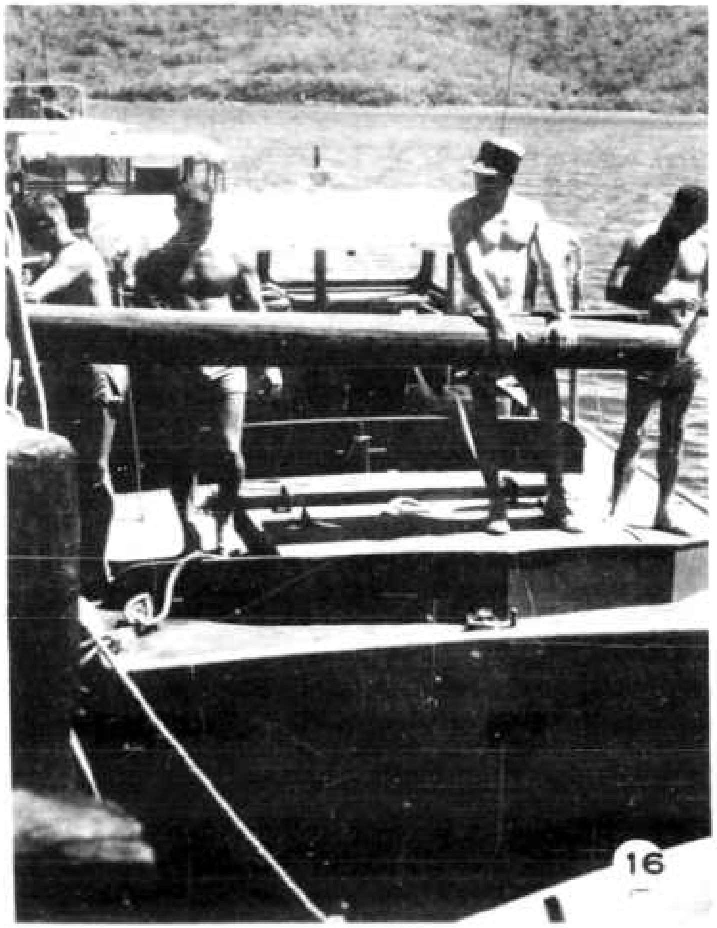

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17

provided. It was made of heavy canvas, had a sturdy wooden pole across one end, 14 batons about 10 inches apart across its hull with a piece of 5/8 inch nylon sewn into a roll across the other end and 12 "Stops" (lines about 18" long with knotted ends) attached in three rows of four each to the batons.

The transom of the pickup boat was equipped with 3 welded brackets into which the pole across the front end of the drag-ramp fitted and was secured with 2 quick-attach bolts. Photograph (16) shows the rolled up drag-ramp about to be lowered into position and attached to the fittings which are visible on the stern.

Even at such slow speeds as 5 or 6 knots it is easy to stand on the ramp. The faster the ramp is towed across the water the more solid the footing becomes and an increasing number of persons can stand on it simultaneously.

With the above described equipment installed on the 40 foot turbine-driven craft, a series of tests was initiated, first at slow speeds with one man per sled, gradually increasing both. From the start it was apparent that application of the equipment and technique to the operational boat offered no major difficulty. Although the craft's freeboard was considerably higher than that of the small speedboat originally used, the float-line slid right up the line-guide. Occasionally it would fail to enter the slot in the top of the winch, bouncing forward under impact with the "shoe". A temporary, field-expedient-fix was made, eliminating the curve on the front face of the shoe, making it an inclined plane instead, and the problem was eliminated.

The line henceforth dropped immediately into the slot where it consistently locked in the jaws.

The 2,000 lb. test float-line was satisfactory for the lighter initial loads (8 foot sleds with maximum of 4 swimmers per sled) but proved marginal for use with the 10 foot sleds and more swimmers. The fact that it was of a laid-rope design also made it prone to coil and tangle.

The winch worked satisfactorily throughout the tests.

The rollers on the horns soon became inoperative with salt in the bearings. The float-line however, continued to slide around their grooved base, demonstrating that the roller was superfluous. Their location and the angle at which the horns were mounted on the deck proved important and was modified several times until the optimum position was ascertained. They had to be canted at a slight outboard angle yet located far enough inboard so they would not strike the dock when coming alongside.

The drag-ramp, performed well not only for boarding but also proved to be an excellent ramp for "casting" the swimmers. The coxcomb, churned up by the propeller and transom is a swirling mixture of water and air and going into it is like jumping on a feather bed. This was an unexpected operational dividend of the pickup system.

The sleds varied considerably in their performance. The single 8 foot pram with a vee-bottom, blunt nose and wide floatation-ring had surprisingly bad yaw characteristics and quickly ruled itself out. The two round-bottom 8 foot sleds worked very well when loaded with 4 men in each but were too

cramped with more. Their yaw characteristics were good and they readily rose to the surface when the intercept occured. The floatation ring was in good proportion to their size, the sleds lying just flush with the surface of the water with 4 men aboard (see photograph (13)).

The hand-holes cut thru the sides also weakened the structure to the point where the swimmers pulling on them caused cracks to extend into the hull. Jets of water also squirted thru the hand-holds into the swimmers faces, making it difficult for them to see at high speeds.

The ten foot sleds performed best of all but appeared to have a maximum operating capacity of 8 men. Their floatation was satisfactorily but once again the hand-holds were troublesome.

A total of 19 pickups were performed in Chesapeake Bay off Little Creek in comparatively smooth water (not exceeding Sea-State 3). It was definitely proven that the system was applicable to Naval craft, was superior to existing methods and required only relatively minor modifications. Sufficient experience was accumulated to terminate the tests and start preparations for Phase III.

PHASE III -- OPERATIONAL PHASE

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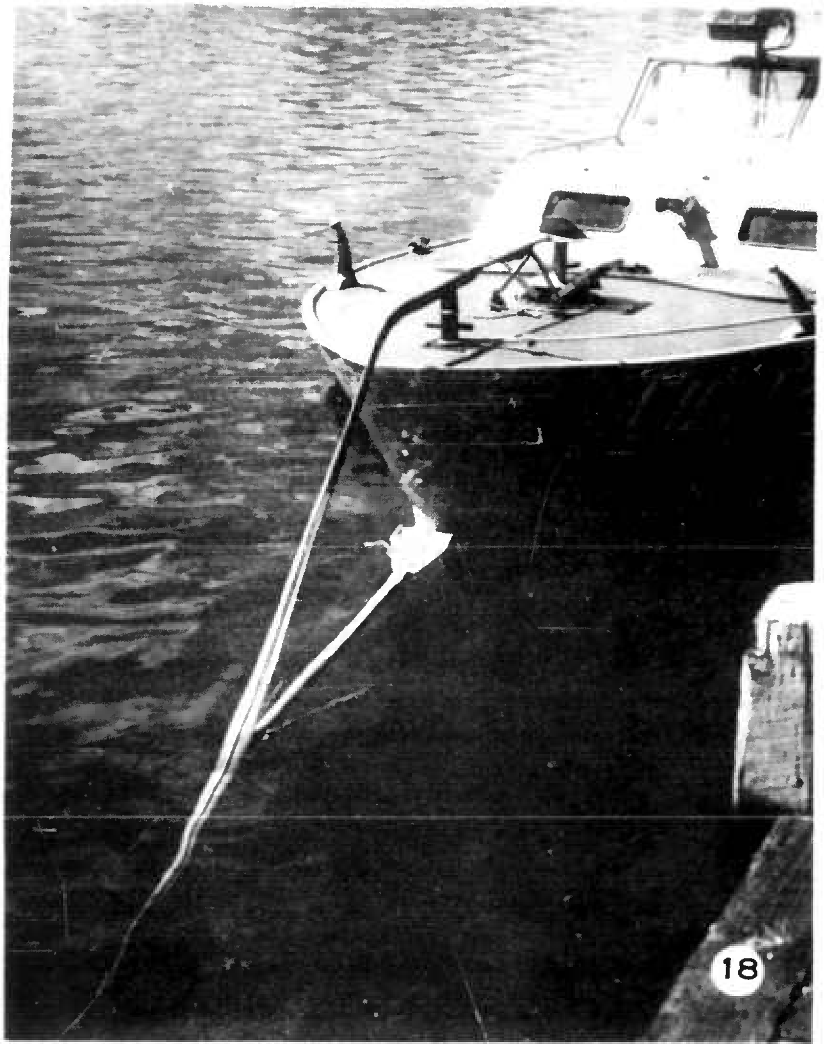
The purpose of this phase was to create a relatively final set of equipment, subject it to full-scale operational type tests, and use it to develop techniques such as would be used on an actual mission.

The equipment tested in Phase II was modified and augmented in the following particulars:

* The winch mounting plate was tipped forward to make it easier for the float-line to enter the slot in the top flange of the drum and secure itself in the jaws (see photographs 18, 19 and 20).
* The shape of the shoe on top of the winch drum was reshaped for the same reasons.
* The size of the drum was augmented to provide for a stronger float-line.
* The angular travel of the level-wind arms was increased for the same reason.
* The test-strength of the float-line was increased from 3,000 to 6,000 lbs. and its construction was changed to a splicable, braided type.
* A loop was added at each end of the float-line and a pelican-hook was used to reef the loops so that failure on the part of the coxswain to intercept



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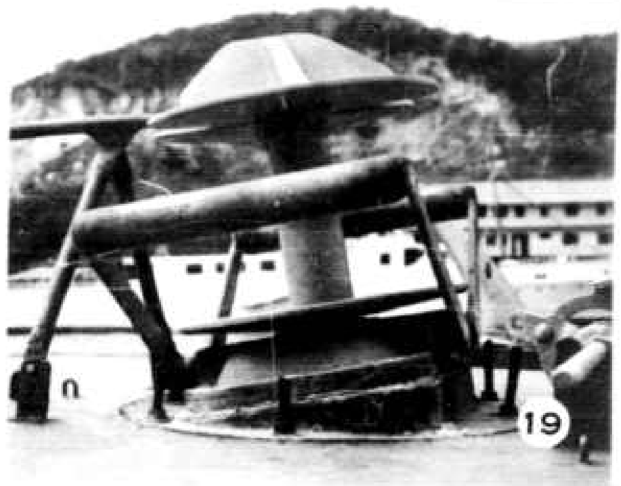

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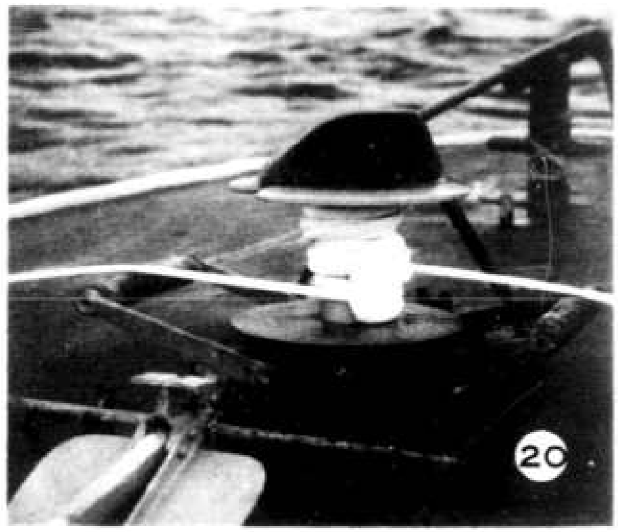

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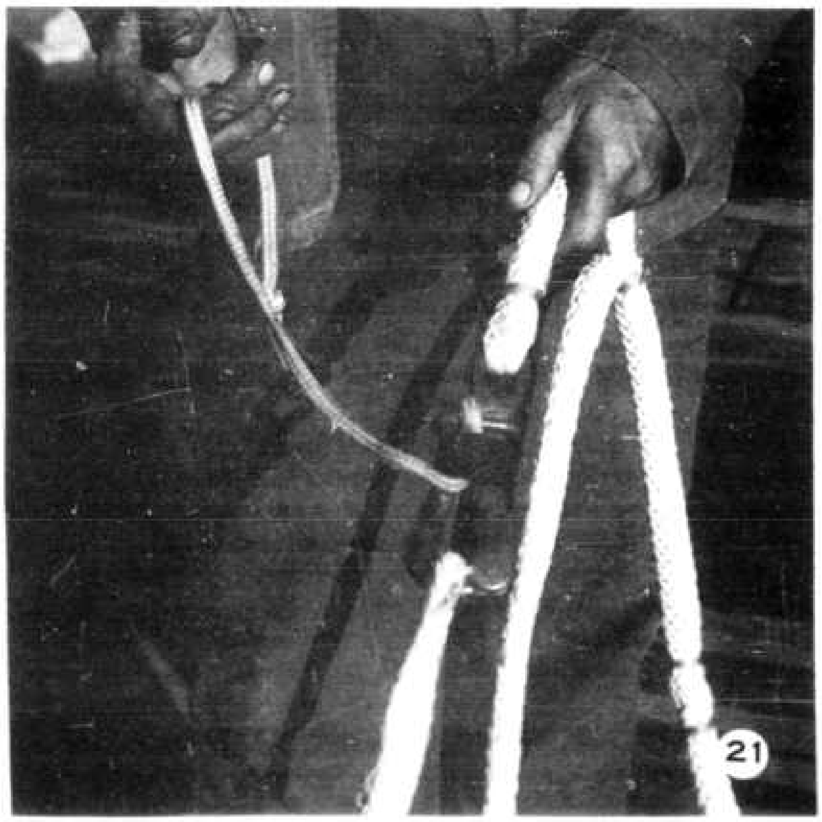

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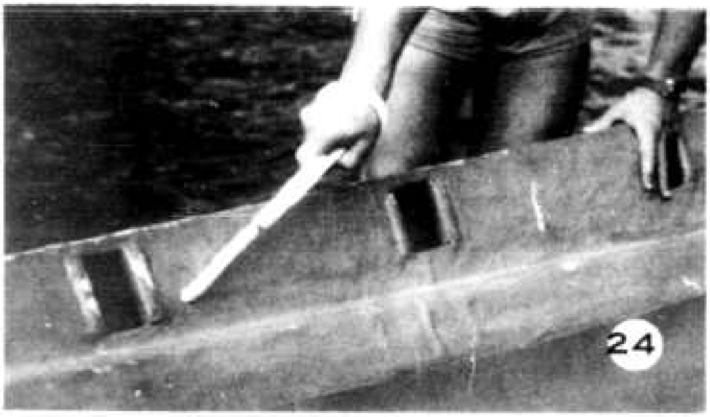
the float-line in the center (thereby not bringing the sleds simultaneously up to the drag-ramp) could be compensated for by opening the pelican-hook and extending the length of the short side (see photograph 21).

* A float-marker was added to the center of the float-line to assist the coxswain making the intercept mid-way between the sleds.
* The horns were redesigned to eliminate the rollers and to make them readily removable from the deck when not in use.
* A new pair of 12 foot sleds was constructed with thicker fiberglass layup, a reinforced bottom and stern, and hand-holds integrated into the flotation-ring to eliminate the objectionable spray (see photograph 23.). "Subway straps" were also added, the loops being large enough for safe disengagement when merely released. (See photographs 24 and 25.)

The completed equipment was shipped to UDT 21 at Little Creek, Va., and thence transported to St. Thomas, Virgin Islands, for testing. At that point it was installed on a 36-foot pickup boat and during the following two-month period was subjected to frequent application under a wide variety of conditions. As many as 10 swimmers in one sled and 11 in the other were picked up with the boat travelling at its maximum speed (approximately 25 knots). Sea-states as high as 5 were encountered.


23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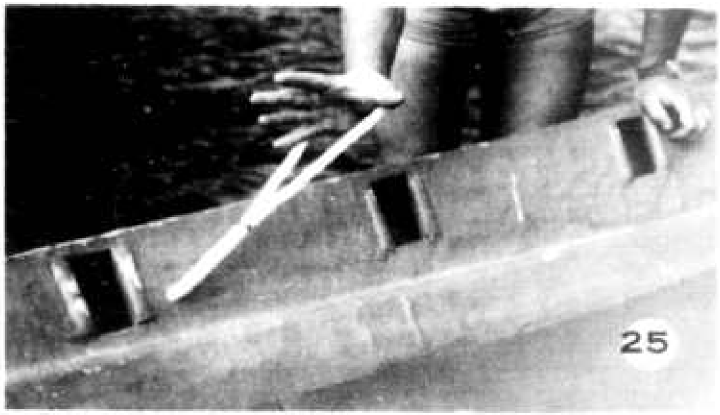
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Tests were carried out to learn what happens if the line-guide rides over the float-line (by virtue of the boat pitching). Despite rough seas this condition could not be induced so the line-guide was deliberately retracted onto the deck and the boat ran directly over the line. In every case it passed smoothly under the keel and the skeg without fouling the propeller, the rudder or the drag-ramp.

The only precaution which it appears necessary to exercise in operating the pickup boat is to avoid backing down over the drag-ramp. The best procedure is to keep the ramp rolled up on the stern until it is required, to roll it up again immediately after it has performed its job. (But lay it out again on the dock to dry it out. Do not leave it rolled up wet and preferably wash it down with fresh water before drying.)

One hazardous condition was observed during these operations. The swimmers frequently had a horse-play tendency to grab the float-line at moments when there was a pause in operations and try to plane on their stomachs or back. The float-line was at that time attached to the sleds by means of a large snap passing thru a hole in a steel fitting secured to the keel in a fore and aft position. If the boat was moving at more than 3 or 4 knots the swimmer could not long hold onto the line. As soon as he let go he was in danger of being snagged and cut by the hook and attach-plate. The design was therefore subsequently modified to eliminate the hook and plate. A hole was cut thru the locally reinforced keel, a recess was created inside the bow of the hull, an eye was spliced into the ends of the float-line and a wooden dowel (secured

with a tie-line to avoid its loss) was passed thru the eye and placed in the recess. By this means the outside of the hull was cleaned up and the hazard removed.

A number of tests were conducted to determine the optimum operational technique for the system. It quickly became apparent that the procedure illustrated in the drawing entitled "Operational Schematic" (see page 4) offered a minimum of exposure of the recovery craft and the swimmers, could be accomplished at flank speed, and led immediately to sea and safety.

****

After conclusion of the St. Thomas test and receipt of UDT 21's official report, it was decided to provide another complete set of gear to UDU 1 at Coronado. This was done both for evaluation purposes and to investigate the problems which might arise as a result of the large amounts of kelp found in Pacific waters.

Two minor modifications were made as a result of this program. A slightly more pointed leading edge was welded along the line-guide. This not only satisfactorily parted the kelp but also reduced the spray as the line-guide moved at high speed thru the water.

The other change was a modification to the float-line. The pelican-hook was eliminated in favor of an eye-splice and a short, separate tie-line cleated to the deck. If one sled reaches

the pickup boat first, it is now simply released from the float-line (the end of which thus becomes free to wind into the winch as the 2nd sled is brought up to the stern) while the tie-line is quickly attached to the eye splice in the painter and the 1st sled is securely retained at the transom. This hook-up eliminates having in the float-line a heavy mass (the pelican hook) which if inadvertantly released flies like a stone out of a slingshot as a result of the energy stored in the taut float-line. It also retains the sled on the drag-ramp, not permitting it to drop back into the wake where it might overturn.

RECOMMENDATIONS FOR PRODUCTION UNITS

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Other problems with the system have been of a relatively minor mechanical nature. The winch output shaft requires redesign to strengthen it by making it from an integral piece of bar stock rather than by an assembly process. The winch gear-ratio should be modified to reduce the draw on the boat's electrical system. The horns can better be made by inserting a tubular extension in their base than by separating the base with a vee construction. The line-guide will be considerably easier to stow when divided into two parts, one for scooping the line from the water and the other for guiding it along the deck.

These improvements can readily be made when additional units are constructed and, in most cases, require no testing.

CONCLUSION

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Conduct of the above described program not only brought the concept to the point of being ready for operational application but also proved it to include the following advantages:

* High speed operation.
* Minimum exposure to enemy fire.
* A highly maneuverable, evasive target (not obliged to hold a long straight course during protracted individual swimmer pickups).
* No highly precise boat maneuvering necessary (as with other systems to get close -- but not too close -- to every swimmer. Coxwain has one hundred feet or more of latitude in intercepting float-line.
* Less dangerous for swimmers.
* Minimum strength and coordination required of swimmers at moment of pickup after an already exhausting operation. Even an injured and unconscious man can be placed and held in the sled by his buddies and brought aboard the pickup boat when safely out of enemy range.

* Little danger of missing a swimmer and having to subject the whole operation to further enemy action by turning back.
* Improved rough water performance due to elimination of need to pass close to swimmers.
* Improved night performance, (possibly using ultra-violet "black light") still at high speed and without hazard of running down the swimmers.
* Low acceleration forces resulting in elimination of injuries caused by high shock loads of other systesm.
* Better chance of all swimmers returning and of getting a more complete reconnaissance report.
* An improved method of "casting" as well as "recovering".

OTHER POTENTIAL APPLICATIONS

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The operational principals and techniques which make this system successful for swimmer pickup are potentially adaptable to other recovery operations requiring motion and speed.

A ready example is open-water resupply in instances where it is desirable to perform the operation while under way, preferably at considerable speed. Another is the recovery of floating objects such as sonobuoys, practice torpedos, etc.

In certain instances some of the existing hardware designed for swimmer recovery might even be applicable.

It is recommended that the potentialities of the system be kept in mind for all applications involving recovery where hazard would result from stopping or even slowing down the recovery craft.